The Interplay among Black Holes, Stars and ISM
in Galactic Nuclei
Proceedings IAU Symposium No. 222, 2004
Th. Storchi Bergmann, L.C. Ho & H.R. Schmitt, eds.

DOI: 00.0000/X000000000000000X

Blue colours of BL Lac host galaxies

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Abstract. Near-infrared and optical imaging of BL Lac host galaxies is used to investigate their colour properties. We find that the R–H colour and colour gradient distributions of the BL Lac hosts are much wider than those for normal ellipticals, and many objects have very blue hosts and/or steep colour gradients. The blue colours are most likely caused by recent star formation. The lack of obvious signs of interaction may, however, require a significant time delay between the interaction event with associated star formation episodes and the onset of the nuclear activity.

1. Introduction

Optical imaging of low redshift (z < 0.5) BL Lac objects (e.g. Falomo & Kotilainen 1999; Urry et al. 2000) has shown that virtually all of them are hosted in luminous ellipticals, with characteristics indistinguishable from those of inactive massive ellipticals. On the other hand, near-infrared (NIR) imaging has only been available for small samples of BL Lacs (Kotilainen et al. 1998 [K98]; Scarpa et al. 2000 [S00]; Cheung et al. 2003 [C03]). We present deep high spatial resolution (∼0.7 arcsec FWHM) NIR H–band (1.65 μm) imaging of 23 low redshift (z < 0.3) BL Lacs that were previously investigated in the optical R-band (references above). We combine them with previous data to form a sample of 41 BL Lacs with which to investigate the optical-NIR colour properties of the BL Lac hosts and to compare them with radio galaxies (RG) and inactive ellipticals. Full report is given in Kotilainen & Falomo (2004).

2. Host galaxy colours and colour gradients

It is well known that the colours of elliptical galaxies become bluer towards fainter magnitudes (e.g. Kodama & Arimoto 1997). This colour–magnitude (C-M) relation may depend on age and metallicity. Fig. 1 (left panel) shows the optical-NIR C-M relation of the BL Lac hosts, compared with ellipticals in clusters (Bower et al. 1992). BL Lac hosts exhibit a much broader range of colours, and they are systematically bluer than inactive ellipticals. This behaviour is similar to that found for low redshift RGs (Govoni et al. 2000) and quasar hosts (Jahnke et al. 2004). This trend could be explained if the C-M relation for ellipticals breaks down at the highest luminosities. Indeed, the BL Lac hosts cover the bright end of the luminosity function of ellipticals. However, although very few of the ellipticals are equally luminous, those few exhibit red colours. Therefore, if the C-M relation of ellipticals extends to high luminosity, the obvious explanation for the blue colours is recent star formation (SF). The broad range of colours then reflects differences in the SF epoch, from most recent SF episodes (blue) to old stellar populations (red).

Inactive ellipticals have negative colour gradients (bluer with increasing radius) due to age and metallicity gradients (e.g. Tamura et al. 2000). The BL Lac hosts (and RGs; Govoni et al. 2000) show on average also a negative colour gradient (Fig. 1, right panel), which is steeper and has a wider spread than that exhibited by inactive ellipticals (Peletier et

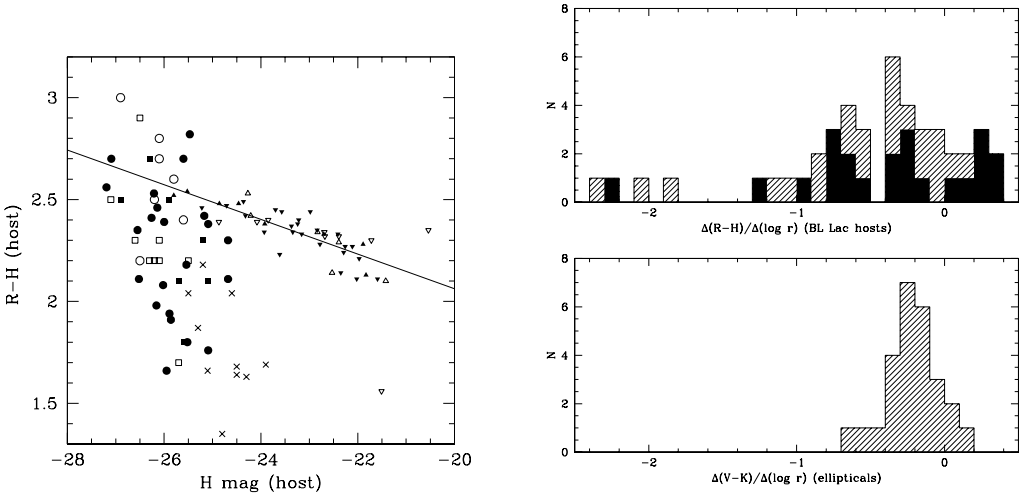

Figure 1. Left: The *R–H* vs. *H* C-M diagram for the BL Lac host galaxies in this work (filled circles), K98 (filled squares), S00 (open squares) and C03 (open circles). The other symbols indicate low redshift (z < 0.2) elliptical quasar hosts (crosses; Jahnke et al. 2004) and elliptical galaxies in Virgo and Coma clusters (small triangles; Bower et al. 1992). The solid line shows the best–fit for the ellipticals. **Right:** Histogram of the *R-H* colour gradient for the BL Lac hosts (top) and for inactive ellipticals (bottom; Peletier et al. 1990; Schombert et al. 1993). The solid histogram shows the BL Lacs in this work.

al. 1990; Schombert et al. 1993). Intriguingly, we find a significant tail in the distribution with very strong negative gradients. These could be either intrinsic or due to central dust extinction in the host galaxies. Significant amount of dust in RGs has indeed been detected as dust lanes or dusty disks (Capetti et al. 2000).

If the blue colours are caused by a young stellar population component, they may signify the link between the interaction/merging event that triggered nuclear activity and rejuvenated the stellar population. However, optical and NIR images of BL Lac hosts show few obvious signs of interaction (e.g. tidal tails, asymmetries). This may necessitate a significant time delay (> 100 Myr) between the SF episodes and the onset of the nuclear activity.

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